HNF-28628-FP
Revision 0

Modifying a 60-Year-Old Stack-Sampling System to Meet ANSI N13.1-1999 Equivalency

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

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MODIFYING A 60 YEAR-OLD-STACK-SAMPLING SYSTEM TO MEET ANSI N13.1-1999 EQUIVALENCY

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INTRODUCTION

The 291-T-1 stack was constructed in 1944 to support ongoing missions associated with the Hanford Project. Recent changes in the plant mission required a revision to the existing license of the stack that was operating as a minor emission unit. The Environmental Protection Agency (EPA) and the Washington Department of Health (WDOH) deemed this revision to be a significant modification, thereby requiring the stack to operate to the ANSI N13.1-1999 sampling and monitoring requirements. Because the stack is similar to other stacks on the Hanford site, allowance was made by EPA to demonstrate equivalency to the ANSI standard via calculations in lieu of actual testing. Calculations were allowed for determining the deposition, nozzle transmission and aspiration ratios, but measurements were required for the stack flow coefficient of variation (COV). The equivalency determination was to be based on the requirements of Table 6 of the ANSI N13.1-1999 Standard.

STACK DESCRIPTION

The stack was designed and built as an annular stack, meaning there is an inner stack constructed of brick and an outer shell of concrete. The inner brick portion is referred to as the liner; the outer concrete portion is referred to as the shell. An annulus exists between the liner and the shell. The annulus is approximately 12-inches wide at the bottom but is narrower at the top of the stack. The stack is 200-feet high and has an outside diameter of 13 feet 10 3/8 inches at the base that tapers to a diameter of 7 feet 6 inches at the top. The sample insertion point is located at the 50-foot level. The internal diameter of the stack at the sample point is 6 feet 6 inches. Flanges available for insertion of the sample probe are 4 inches in diameter in the shell and 3 inches in diameter in the liner. These flanges limit the sample probe design.

PROBE DESCRIPTION

The stack probe used for operation as a potential impact category (PIC) II stack complied with ANSI N13.1-1969 criteria. The probe, a rake design with ten nozzles was installed in the mid-1980s and measured equal annular area as described in the standard. The probe was designed to provide near isokinetic sampling. The associated sample line was 0.75-inch outside diameter tubing with several bends as shown in Figure 1.

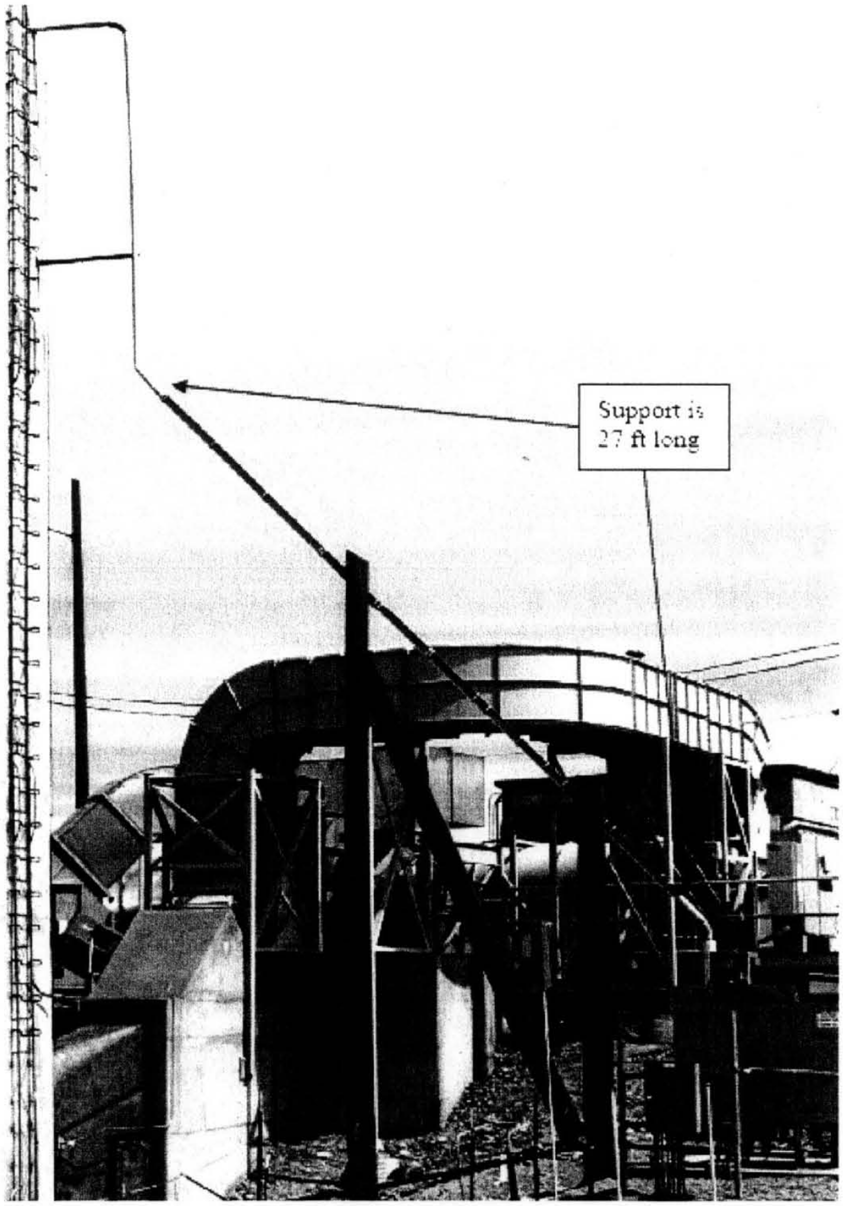

Figure 1. 291-T-1 Stack Sample Transport Line

The probe and transport line had to be replaced to meet the 1999 standard for a PIC 1 stack. The 3-inch insertion port limited the design of the sample probe. A shrouded probe, as recommended in the Standard could not be used. The required first-bend curvature ratio of 3 could not be used and was limited to 1.7 as discussed in the following pages. The new design incorporated a 1 inch probe/line and eliminated one of the transport line bends as shown in Figure 2.

Figure 2. New Sample Transport Line for 291-T-1

EQUIVALENCY REQUIREMENTS

The ANSI Standard requires injection of tracer gases and particulates that are then measured at the sampling plane to determine compliance to the Standard. Due to the height of the sample insertion point and the restricted access of a 3-inch port located in the inner liner, discussions with EPA and WDOH were held to determine a graded approach to the equivalency demonstration. The criteria were agreed upon are given below:

- Equivalency will be based on ANSI N13.1-1999 Table 6 criteria.
- Calculated transport, transmission, and aspiration values will be accepted in lieu of actual measurements.
- Flow traverse to determine the Coefficient of Variation (COV) will be taken in one direction only.
- Verification that the average flow angle does not exceed 20 degrees will not be performed due to the design constraints of the stack.
- Acceptance of the sampling location will be based on the absence of observed flow asymmetries in the cross section of similar stacks and verification that the Velocity COV is <20%.

Equivalency Demonstration to Table 6 requirements

Performance Criterion #1

Total transport of 10 μm average diameter (AD) particles and vaporous contaminants shall be >50% from the free stream to the collector/analyzer.

Calculations were performed using computer code Deposition 2001.a (a revision to Deposition 4.0). Five cases were considered to account for the range of sample flow rates and operating conditions. A first-bend curvature ratio of 1.724 was used instead of the required ratio of 3 due to the space constraint of the 3-inch opening for probe insertion. A 1% loss is credited to the line through the flow splitter in the cabinet. In all cases, the deposition values were >50% as shown.

Case	1	2	3	4	5
Deposition ratio	.51	.56	.54	.59	.55

Performance Criterion #2

Sampler nozzle inlet shall have a transmission ratio between 80% and 130% for 10μm AD particles.

Transmission ratio calculations were performed using computer code Deposition 2001.a for each of the five cases considered. In all cases, the ratio is between .80 and 1.30.

Case	1	2	3	4	5
Transmission ratio	.98	.98	1.06	1.03	1.01

Performance Criterion #3

Sampler nozzle shall have an aspiration ratio that does not exceed 150% for 10μm AD particles.

Aspiration ratio calculations were performed using computer code Deposition 2001.a for each of the five cases considered. In all cases the ratio is between .8 and 1.3.

Case	1	2	3	4	5
Aspiration ratio	1.01	.99	1.08	1.05	1.03

Performance Criterion #4

The following are characteristics of a suitable sampling location are:

a) COV over the central two thirds area of the cross section ≤ 20% for 10μm AD particles, gaseous tracer, and gas velocity.
b) Flow angle <20° relative to the long axis of the stack and nozzle inlet.
c) The tracer gas concentration shall not vary from the mean >30% at any point on a 40 CFR 60 Appendix Method 1 velocity mapping grid.

a) As agreed to with EPA and WDOH, a flow traverse to determine the COV taken in one direction only is acceptable, as flow asymmetries in the stack cross section were not seen in stacks of similar configuration. The COV across the central two thirds area of the stack was measured to be 14%.
b) This measurement was not performed due to the physical limitations of the sample port. However, due to the high Reynolds number of the stack (5E05) and the fact that flow asymmetries have not been observed in similar stacks, the stream is well mixed at the sampling point.
c) Not applicable, as gases are not emitted.

Performance Criterion #5

Effluent flow rate continuous measurement required if flow variation is >± 20% in a year.

Not applicable. An alternative method for stack flow measurement is approved allowing for use of maximum fan capacity flow.

Performance Criterion #6

Effluent and sample flow rate shall be measured within ±10%.

Not applicable for effluent flow rate as an alternative method is approved.

The sample flow rate is measured continuously using a calibrated mass flow meter to achieve an accuracy of ± 4%.

Performance Criterion #7

Continuous sample flow rate measurement and control required if flow varies >±20% during a sample interval. Flow control shall be within ±15%.

The stack is PIC 1, therefore the sample flow rate is measured continuously using a calibrated mass flow meter.
A flow alarm activates if the flow falls below 15% nominal flow.
Performance Criterion #8

PIC 1: Continuous measurement of effluent flow rate and continuous measurement and control of sampling flow rate (to track flow rate in stack and duct within ±20% of a predetermined value).

Not applicable as an alternative method is approved.

Performance Criterion #9

Periodic inspections of nozzles, transport lines, sample, and effluent flow meters shall be conducted.

Annual maintenance and inspections are performed to meet this criterion.

Performance Criterion #10

Periodic calibrations of effluent and sample flow meters, CAMS, and sample analysis instrumentation shall be conducted.

The stack sampling instrumentation is calibrated and certified using approved procedures traceable to National Institute of Standards and Technology (NIST) or other nationally accepted standard where no NIST standard exists.

Data collection

A slight decrease is seen when comparing the average stack sample values to those obtained the old sample system and the new system. This is expected as the new system is clean and has no deposition buildup.

Table 1 Comparison of average sample values of old vs. new probes

	Total Alpha (uCi/ml)	Total Beta/gamma (uCi/ml)
old probe average	2.0E-15	3.6E-15
new probe average	1.1E-15	2.8E-15

CONCLUSION

The 291-T-1 stack sampling system meets the substantive performance requirements of Table 6, ANSI N13.1-1999. Sample results show that adequate sampling is being performed by the new stack sampling system.

REFERENCES

HNF-29175, P. M. O'Brien and D. E. Schoepflin, "291-T-1 Stack Equivalency Demonstration to ANSI n13.1-1999," March 14, 2006.

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